METHODS OF RECORDING MESHING MARKS AND SURFACE DEFECTS ON GEARS

BY

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During the past 10 years the tooth loading of naval gears, expressed as the ' K ' factor*, has risen from 70 to over 200. In case hardened and ground gears, which will be introduced into Fleet service during the next 5 years, ' K ' factors of 450 have been accepted. These high loadings are made possible by the use of harder and stronger materials, but can be accepted only if very high standards of accuracy are achieved, both in the cutting of the gear teeth and in the alignment of the meshing elements. Although modern methods of boring lines of bearings and measuring alignment of housings ensure reasonable initial alignment, it is necessary to make checks. The only method of checking and adjusting final alignment, which is sufficiently sensitive, is to mesh the elements together with suitable marking applied to the teeth and examine the signatures obtained. In this way, differences of 0·0001 in, in tooth flank alignment of gear cutting, can be detected without difficulty. The method of interpreting marking is beyond the scope of this article and is described in D.E.T.M. 43 ; here, we are concerned with the methods of marking available, in which considerable advances have been made recently.

Marking for Static Meshing

For this purpose a soft dye is applied to the teeth of one of the meshing elements and the gears are turned in mesh, causing marking to be transferred where contact takes place, but to remain on the original teeth where there is no contact. Toolmakers' blue or red marking is suitable, but it is essential that it should be applied very thinly. Both on the Continent and in North America two-colour marking is used. Blue marking is applied to one element, red to the other, and the consequent signatures after transfer stand out in contrast. This technique is superior to single colour marking and is being introduced into Admiralty practice.

Marking under Torque While Running

While static marking signatures confirm that the gear tooth surfaces have been machined as specified and aligned correctly, the final proof of good contact in service must be the marking when running under torque. In the past,

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**Note:*

The ' K ' factor is a convenient method of comparing the load carried by gears of the same general type and size range. It is related to the surface stress and may be defined as :—

$$K = \frac{Ft}{d} \times \frac{(R + 1)}{(R)}$$

where Ft = Tangential load in lb/in of face width
d = Pitch circle diameter of pinion
R = Gear reduction ratio

gear engineers relied on the natural marking of the untreated metal surfaces. This was difficult to interpret as the angle of lighting can have a considerable effect on what is seen and the difficulty is increased when the tooth surfaces are very hard. It is also impracticable to assess the marking if the gears have been run previously. An early method for providing a surface treatment to give clear marking under load was to obtain a soft coating on the teeth by painting them with copper sulphate. The deposited copper gives a good signature, but the method is dangerous and little used because of copper penetration along grain boundaries and the possibility of corrosion.

The method used at present for Admiralty work, is to paint bands of teeth with ' Talbot Blue ', a hard-setting blue lacquer which rubs off under contact and gives a clear picture of the development of marking along the flank as the load increases. The film is extremely thin and is difficult to measure even with a high grade comparator. It is durable, and satisfactory interpretation can still be obtained after several hours running. This method distinguishes between areas of contact and no contact, but will not show the distribution of load in the contact area. It has been in common use since the original *Daring* machinery trials at Pametrada, in 1949, and is now universal for both shore tests and sea trials. Details of the lacquer and the way of applying it are to be found in D.E.T.M.43. Other methods include electrolytic plating techniques one of which, developed in the United States and in use at the U.S. Naval Boiler and Turbine Laboratory, Philadelphia, is under investigation. It is claimed that this method allows some assessment of distribution of load.

Recording of Tooth Marking and Defects

It should never be necessary to make amateur pencil sketches of gear teeth, which eventually reach the person who has to interpret them either dirty and dog-eared or invalidated by re-drawing. Photographs, particularly of pitting and other surface defects, are expensive and liable to give a false impression unless the lighting is just right. Where blue or red marking has been applied to teeth an accurate permanent record of the surface appearance, including the spread of marking, can be made by placing a piece of selotape (or ' Scotch ' tape) sticky side to the tooth. When withdrawn, the tape bears a perfect two-dimensional record of the tooth surface which may be stuck to a piece of white paper for filing. Such records are easy to study and can be kept indefinitely. The best results are obtained when the minimum of marking is used. A cruder method of getting a quick, accurate, two-dimensional picture of surface defects is to take a pencil rubbing of the tooth surface. This is, however, much less effective. Plastic tape records cannot be taken from Talbot Blue marking, but a permanent record can be obtained in the following manner :—

(*a*) Rub the tooth thoroughly with a dry rag to remove as much oil as possible.

(*b*) Take a small strip of semi-absorbent duplicating paper large enough to cover the tooth surface. With helical gears, it is preferable to use a curved strip so that it will fit the tooth surface neatly.

(*c*) Apply the paper to the tooth ; securing each end with selotape will help.

(*d*) Take a small pad of cloth and damp with methylated spirits—the pad should be almost dry.

(*e*) Press pad on to the back of the paper for a second or so, working gradually along the tooth.

(*f*) The paper will be damped with the spirit and the Talbot Blue will be softened instantly and adhere to the paper. Care has to be taken to avoid putting too much spirit on the paper, as this will give a poor record.

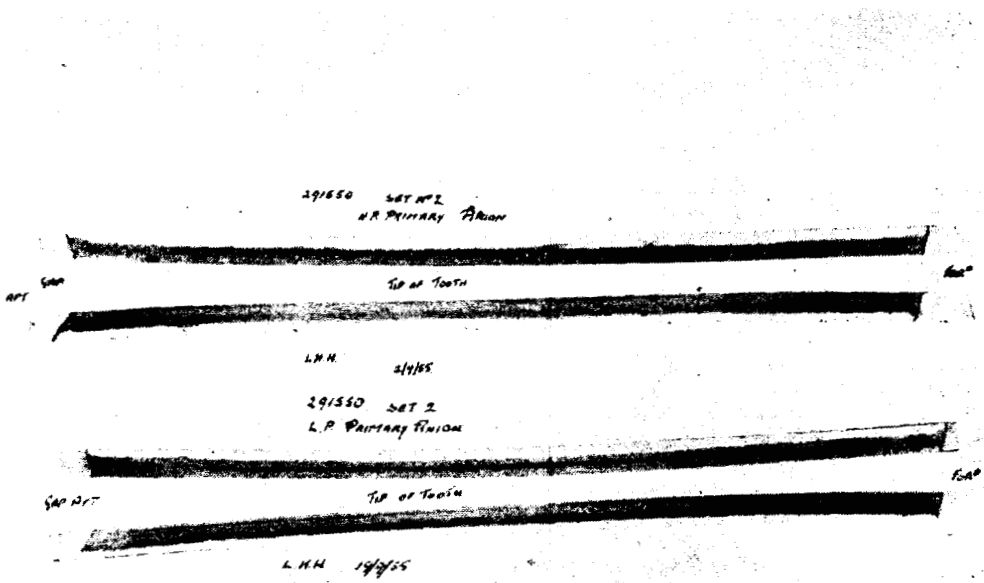

FIG. 1—TYPICAL SELOTAPE RECORD OF TOOTH CONTACT MARKING

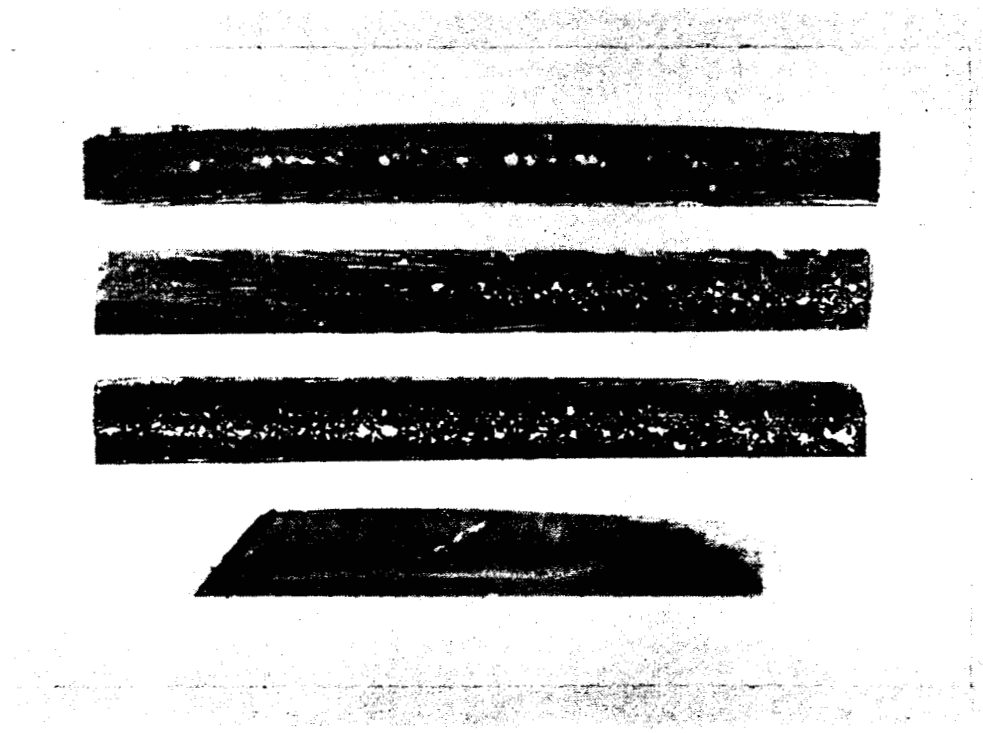

FIG. 2—SELOTAPE RECORDS OF TOOTH CONTACT. UPPER THREE SHOW TYPICAL RECORDS OF PITTING AND LOWER ONE, LIGHT SCUFFING

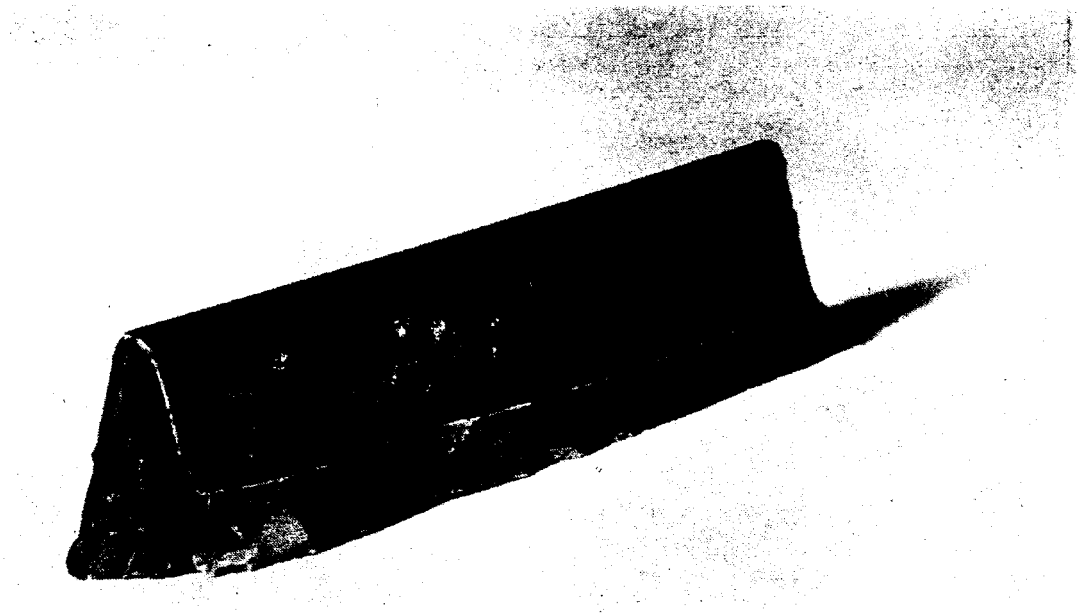

FIG. 3—MARKO REPLICA OF PITTED GEAR TOOTH

(*g*) When the paper is removed, a permanent record of the marking will be obtained.

For three-dimensional records, castings of the tooth surface are taken to obtain a ' negative ' replica. Sulphur was the original material used and gives good results, but the casts are too soft to enable surface roughness records to be made with a Tallysurf or similar instrument. Various proprietary plastic resins exist for this purpose, the one used by the Admiralty being known as ' Markokit'. This gives an excellent permanent replica which is dimensionally stable and hard enough to resist a Tallysurf stylus. The material is expensive and has a limited shelf life, so its use is restricted. Special arrangements are made by the Admiralty to supply the material where records are required.

The photographs with this article show :—

FIG. 1—Typical selotape record of tooth contact marking.
FIG. 2—Records of pitting and scuffing.
FIG. 3—Marko replica of pitted gear tooth.

Records of Gearing

The methods of taking records described cover :—

(i) Records of static meshing.
(ii) Records of distribution of load under running conditions.
(iii) Records of tooth defects.

It is therefore possible to use these methods to compile a history of gearing without reliance on memory, sketches, or poor photographs. They will materially assist in maintaining the high degree of operating standards which are essential for the satisfactory operation of heavily loaded marine gears. Such records will be particularly valuable where pitting occurs from local overloading. Comparison of successive plastic tape records on selected teeth will make it possible to assess whether the pitting has stabilized or is still progressive.

It is hoped that these techniques may prove of interest and value to users outside the gear field, who are interested in recording contact and surface markings.